results of experimental cultures, directions for raising various crops with appropriate fertilizers, business maxims, a plea for good roads, etc. It has neither coherence nor apparent object beyond advertising under the guise of a handbook.—C. R. B.

Botanical literature.—Section M of the International Catalogue of Scientific Literature, devoted to botany, was published in July by the Royal Society of London. It contains the literature for 1904, and some belated entries for the preceding three years.[9] The volumes are improving in comprehensiveness and accuracy. Certainly no research laboratory can do without them.—C. R. B.

Volatile oils.—The semi-annual report of SCHIMMEL & Co., dated October-November 1906, contains an unusually extensive statement of the trade conditions respecting the volatile oils and the plants which produce them. Fifty pages also are devoted to a summary of recent researches on terpenes and the terpene derivatives.[10]—C. R. B.

Genera Siphonogamarum.—The ninth fascicle of DALLA TORRE and HARMS[11] list of the genera of seed plants continues the general alphabetical index of names, the last entry being Diplopeltis.—J. M. C.

NOTES FOR STUDENTS

Galvanotropism of roots.—Two studies on this topic appeared almost simultaneously last autumn. SCHELLENBERG investigated the influence of salts on the direction of growth of the roots of peas,[12] using roots of seedlings grown to a length of 3–4^{cm} in moist sawdust and then fixed vertical in very dilute solutions of various salts, with cotyledons exposed. The experimental vessel with the solution was connected by filter-paper bridges with vessels at each side which contained the same solution, and into these were led metallic electrodes with a current of 2–6 volts, and 0.1 to .001 milliampere. Neglecting the effects of stronger currents, which produce curvatures due to death or disturbances of growth, the vast preponderance of response was a turning toward the anode, NH_4Cl alone showing 6 out of 8 curvatures toward the cathode. Chemotropic studies have shown that the reaction changes with concentration; it likewise

[9] International Catalogue of Scientific Literature. Fourth annual issue. M. Botany. Published for the International Council by the Royal Society of London. London: Harrison & Sons. 37*s.* 6*d.*

[10] Semi-annual report of SCHIMMEL & Co. (FRITSCHE BROS.). Miltitz near Leipzig. 12mo. pp. 161. New York: Fritsche Bros. 1906. Free.

[11] DALLA TORRE, C. G. DE, and HARMS, H., Genera Siphonogamarum ad systema Englerianum conscripta. Fasc. 9. pp. 641–720. Leipzig: Wilhelm Englemann. 1907. *M* 6.

[12] SCHELLENBERG, H. C., Untersuchungen über den Einfluss der Salze auf die Wachstumsrichtung der Wurzeln, zunächst an der Erbsenwurzel. Flora **96**:474–500. 1906.

reverses with increasing concentration of solution when an electric current traverses it. Further, the reaction was found to be an additive effect, depending upon the sum of the specific actions of the cathions and the anions. From all the phenomena the author is led to a conclusion, neither novel nor very well founded, that with salts chemotropism and galvanotropism are identical, both being explicable by the migration of ions into the cell and the disturbance of electrical equilibrium they there produce. In chemotropism the migration is due to a concentration gradient, in galvanotropism to the electric current. When non-electrolytes call forth chemotropic responses (as certainly they do) SCHELLENBERG would explain the action by a modification of the permeability of the plasma to the internal salts, whose unequal outward diffusion disturbs the inner electric equilibrium. The experimental work of this paper lacks definiteness and seems to be devoid of sufficient precautions.

GASSNER, working in KNY'S laboratory in Berlin, concludes that galvanotropism is only a form of traumatropism.[13] His seedlings were placed in small boxes with perforated cork bottoms, through which the roots protruded into a vessel of tap water, frequently renewed, and through an equal cross-section of this passed the electric current from carbon electrodes of uniform size. He used the commercial current of 110 volts, up to 17 milliamperes. But as he found current density (strength of current divided by its cross-sections) to be a controlling factor, *caeteris paribus*, he states this always in milliamperes per cm^2. (To this factor SCHELLENBERG seems to have paid no attention.) On that basis the currents used varied from 0.001 ma. to 5 ma., those most used lying below 0.1 ma.

With weakest currents there was no curvature; with currents from a certain density and time of action up, a curvature toward the cathode; with stronger currents or longer time, first a curvature toward the anode in the part above the growing zone, then a paratonic growth-curvature toward the cathode in the growing zone, thus producing S-curvatures; with further increase in current, complete curvature toward the anode, the injury retarding or inhibiting growth on the cathode side even in the growing zone; with still stronger current, partial curvature toward the anode, growth being soon arrested by death; finally, no curvature with currents that cause death too promptly. Differences were observed in the response of different plants to like currents. The positive (toward anode) and negative curvatures are held to be of different nature. The former, earlier in time, is due to injury by reduction of turgor in full-grown cells on the anode side; the latter to retardation of growth on the cathode side of the growing region. (Since a current which will produce only positive curvature in a given time will with longer duration produce negative curvature, it would seem that such a distinction in "nature" could hardly be valid.) The negative curvature is analogous to curvatures due to geotropism, traumatropism, etc., in which the root tip is the percipient part.

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[13] GASSNER, G., Der Galvanotropismus der Wurzeln. Bot. Zeit. **64**[1]: 149–222. *figs. 12.* 1906.

All curvatures, especially the S-ones, are parallel with traumatropic curvatures. GASSNER rejects BRUNCHORST'S explanation (the action of the products of electrolysis, to which in essence SCHELLENBERG adheres) and that of RISCHAWI (accumulation of water on the convex side), claiming that galvanotropism is only a special case of traumatropism, in which the injury to the positive side is probably wrought by the passage of the current, as happens with other semipermeable membranes. Admitting that the electric current probably produces its effects by reason of migration of ions, GASSNER definitely declines to identify galvanotropism with chemotropism, since the latter itself may be only a modified form of traumatropism or indeed of osmotropism. Nor does he think the entry of hydroxyl ions on the anode side can account sufficiently for the injury, because by calculation their amount is infinitely small, and in an experiment rootlets of corn, containing red anthocyan, showed no change of color, though they curved well in a strong current. Rather he would ascribe the injury to the emigration of ions from the plasma.

The observations in these two papers are not so wide apart, nor are the interpretations so antagonistic as they at first appear.—C. R. B.

Paleozoic botany.—In his presentation of the present status of paleozoic botany, SCOTT[14] dismisses the lower cryptogams with the brief space (7 pages) which their recorded occurrence in the paleozoic strata warrants, and devotes the remainder of his article to the Vasculares. He adopts provisionally the division of vascular plants into two phyla, the Lycopsida and the Pteropsida, as proposed by JEFFREY. Under the Lycopsida are ranged the following classes: Sphenophyllales, Equisetales, Psilotales, and Lycopodiales. The first two classes are included under a group name, Articulatae, a propinquity of relationship thus being recognized, which was first pointed out by JEFFREY and subsequently by LIGNIER. In his treatment of the Sphenophyllales the author describes the features of the various types, already for the most part generally known from his textbook. One genus new to the general student is NATHORST'S Pseudobornia from the Upper Devonian of Bear Island, which is regarded by its author as the type of a special class, the Pseudoborniales. It is characterized by highly dichotomously divided and pinnatifid leaves, which have a certain resemblance to fern-fronds, a resemblance which is considered by SCOTT as of sufficient importance to indicate a certain affinity between the sphenophyllaceous stock and that of the Filicales. Unfortunately nothing is yet known of the internal structure of Pseudobornia. The author regards the characters of Psilotum and Tmesipteris as sufficiently distinct from those of the Lycopodiales to warrant their separation as a special class, the Psilotales. Indeed, he is of the opinion that their peculiar sporophylls find their nearest counterpart in those of the Sphenophyllales. The author even states that if he had to choose between lycopodineous and sphenophyllaceous antecedents for his new class he would choose the latter.

[14] SCOTT, D. H., The present position of paleozoic botany. Progressus Rei Botanicae, redigiert von J. P. Lotsy, pp. 139–217. 1906.